

# ATD-1 AND TERMINAL SEQUENCING AND SPACING (TSS) SIMULATION 1 OUTBRIEF TO ATD-1 TEAM

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## Overview

- NASA is doing research with the Federal Aviation Administration (FAA) and other partners to develop advanced PBN procedures, concepts, and automation tools critical to NextGen
- These tools integrate ground and airborne functionality that will enhance and expand the use of PBN
- **This research and development is on-going and prototypes of these tools will be demonstrated during these simulations**







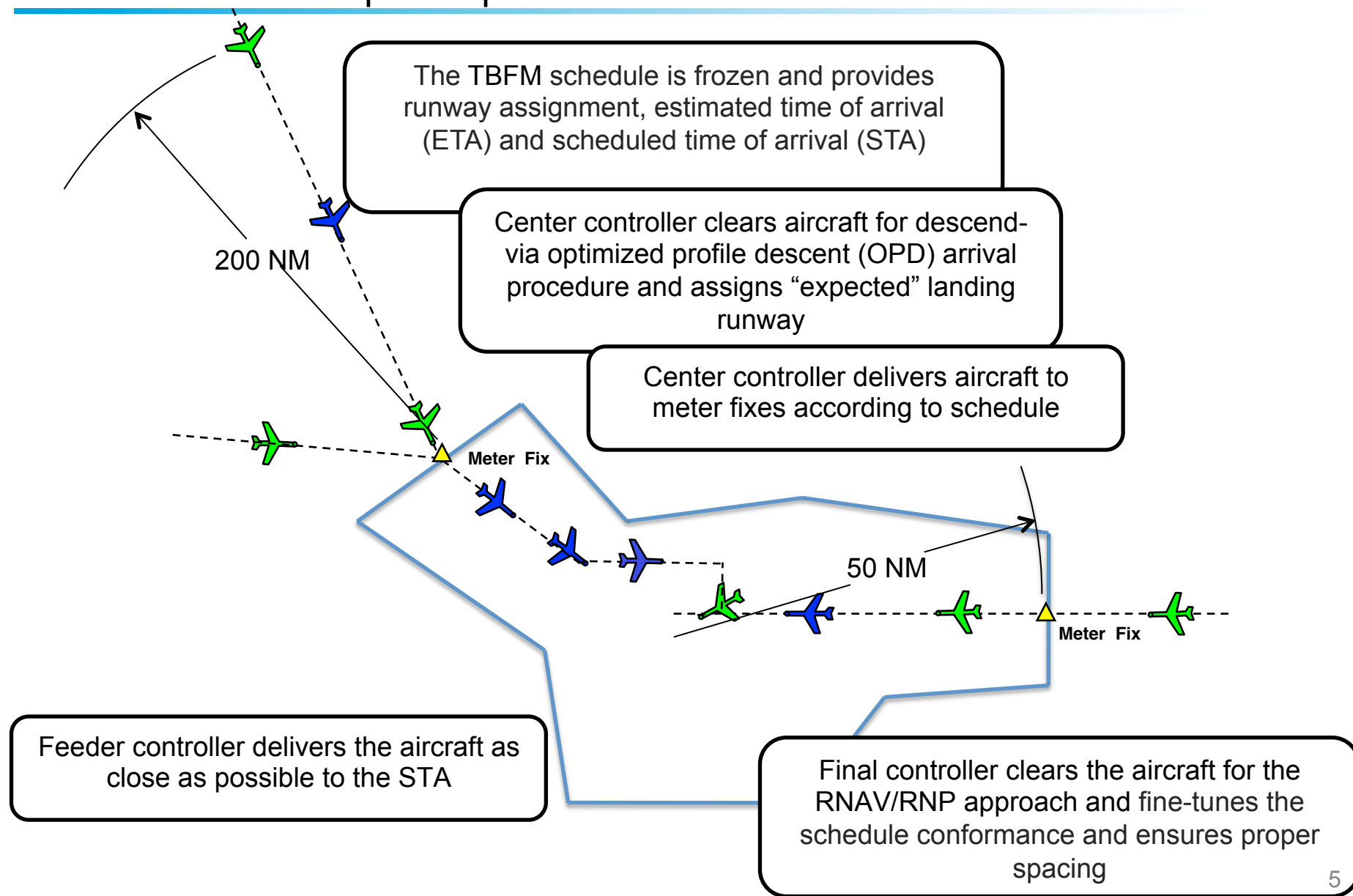
# Objectives

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- Assess the feasibility and evaluate performance of ATD-1 controller technologies for near-term National Airspace System (NAS) application using:
  - Advanced PBN procedures, specifically, Required Navigation Performance-Authorization Required (RNP-AR) terminal arrival procedures
  - Constant radius-to-fix (RF) Legs for airport operations with mixed-equipage
- This will help:
  - Refine the controller/pilot ATD-1 procedures and phraseology
  - Enhance the accuracy and fidelity of ATD-1 tools
  - Determine the effects of wind forecast error or mismatched winds on the ATD-1 tools
  - Assess impact of Time Based Flow Management (TBFM) and TSS tools for enabling the use of RNP-AR with RF Leg procedures during capacity constrained periods for large-sized airports
  - Provide recommendations and enhancements to ATD-1 technologies
  - Determine requirements for future simulations



# ATD-1 Concept of Operations







## Simulation Schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:30 – 9:30	Travel	In Briefing	D Run #1	D Run #6	Travel
9:50 – 10:50		T Run #1	D Run #2	D Run #7	
11:10 – 12:10		T Run #2	D Run #3	D Run #8	
12:30 – 1:30	P Run #1	Lunch	Lunch	Lunch	
1:30 – 2:30	P Run #2	T Run #3	D Run #4	D Run #9	
2:50 – 3:50	P Run #3	T Run #4	D Run #5	D Run #10	
4:10 – 4:45	Debrief	Debrief	Debrief **	Final Brief	

P Run – Pseudo pilot training only, controllers on travel

T Run – Controller Training Run (2 runs for airspace and STARS, 2 runs for tools)

D Run – Data Run

\*\*Debrief followed by BBQ at Harry's house





# Simulation Run Description

Run	Demand	Winds	Tools
T1	1.1	No Winds	SOP
T2	1.1	Winds	SOP
T3	1.1	No Winds	TSS
T4	1.1	Winds	TSS
D1	1.1	Winds	SOP
D2	1.1	Winds	TSS
D3	1.1	No winds	TSS
D4	1.1	No winds	SOP
D5	1.1	Mismatched winds	TSS
D6	1.1	Mismatched winds	TSS
D7	1.1	No winds	SOP
D8	1.1	No winds	TSS
D9	1.1	Winds	SOP
D10	1.1	Winds	TSS

## Baseline

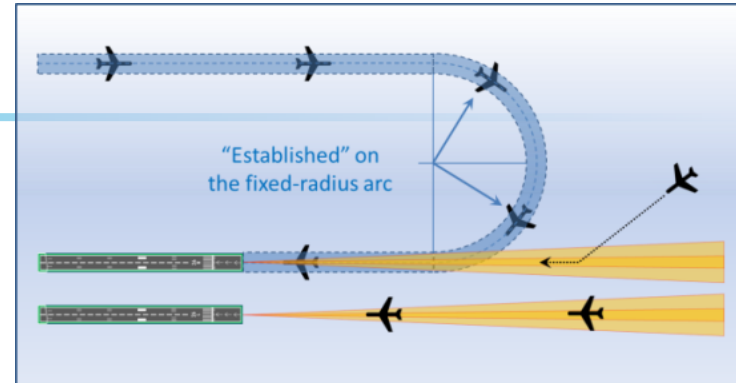
- Normal SOPs
- **'/W'** aircraft equipment suffix will be used to indicate that the aircraft is RNP-AR capable
- A default runway in the scenario is displayed
- Controllers can use existing automation to assist in managing traffic

## TSS (ATD-1) Tools

- Timelines
- Early/late indicator or speed advisories
- Slot markers with their IAS



## Simulation Guidelines



- All aircraft have RNAV capability
- RNP-AR have /W equipment suffix
- TSS tools should be used to avoid vectoring preferencing speed control
- Side-by-side turns to final at the same altitude are considered separated as long as the aircraft is established on an RNAV or RNP approach
- Once an aircraft starts the RNP-AR, any vectors or speed changes will cause the aircraft to come off the procedure, and the aircraft will have to be vectored to final
- No additional spacing is required to the Tower
- The TSS schedule has wake vortex separation built into it and an additional 3 tenths of a mile buffer at the runway threshold
- Aircraft are your control on contact
- There are no missed approaches, fly runway heading, previous research has been dedicated to TSS automation to support missed approach operations
- Controller-to-controller coordination should be done by radio communications





## Controller Positions

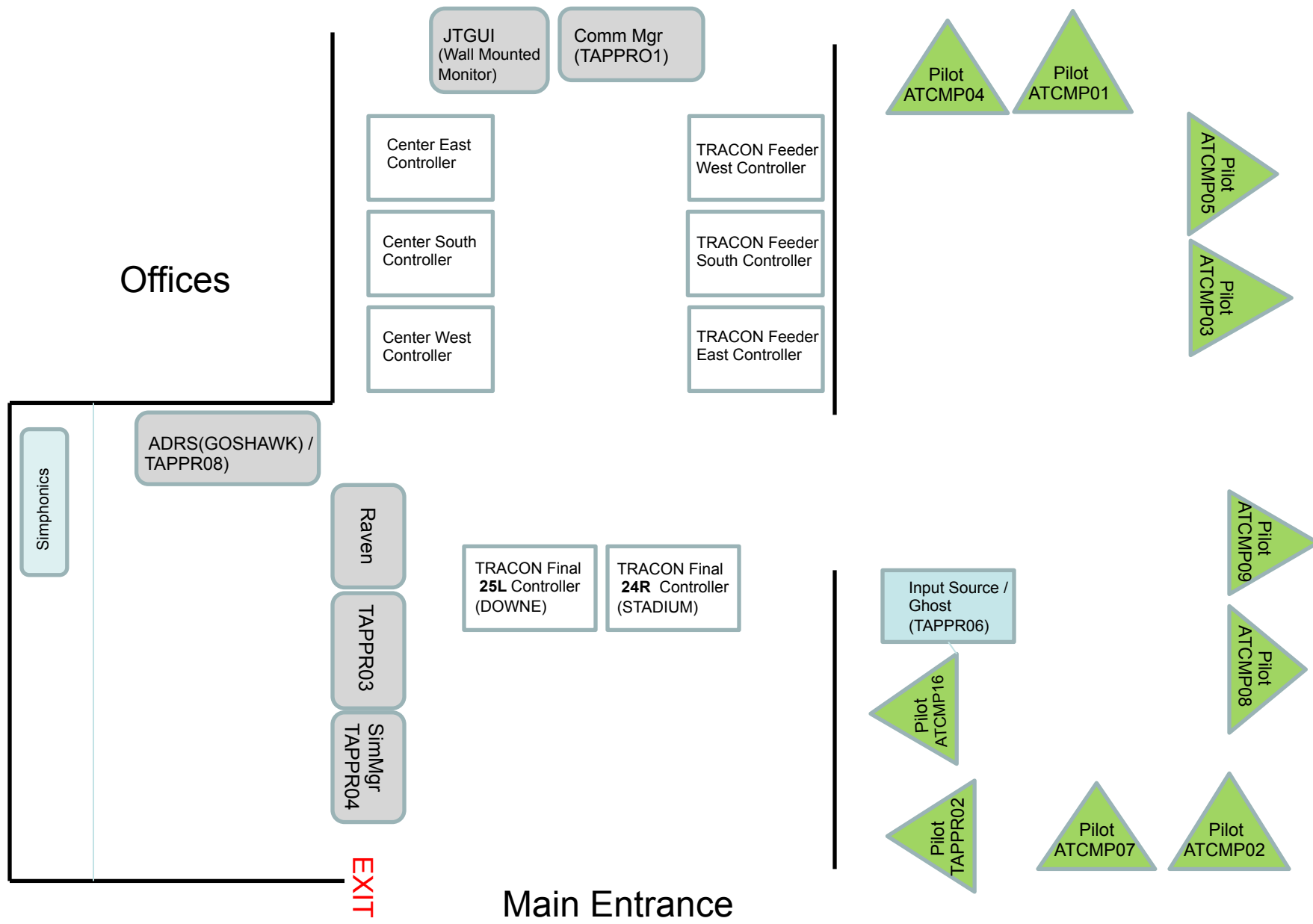
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- **ZLA Center**
  - Three Controllers
    - ZLA Center West (Confederate Controller with ZLA experience)
    - ZLA Center South (Confederate Controller with ZLA experience)
    - ZLA Center East (Confederate Controller with ZLA experience)
- **TRACON Feeder** (TSS tools)
  - Three Controllers
    - West/ZUMA Feeder
    - South/Pacific Feeder (Confederate with LAX TRACON experience)
    - East Feeder
- **TRACON Final** (TSS tools)
  - Two Controllers
    - 25L DOWNE
    - 24R STADIUM



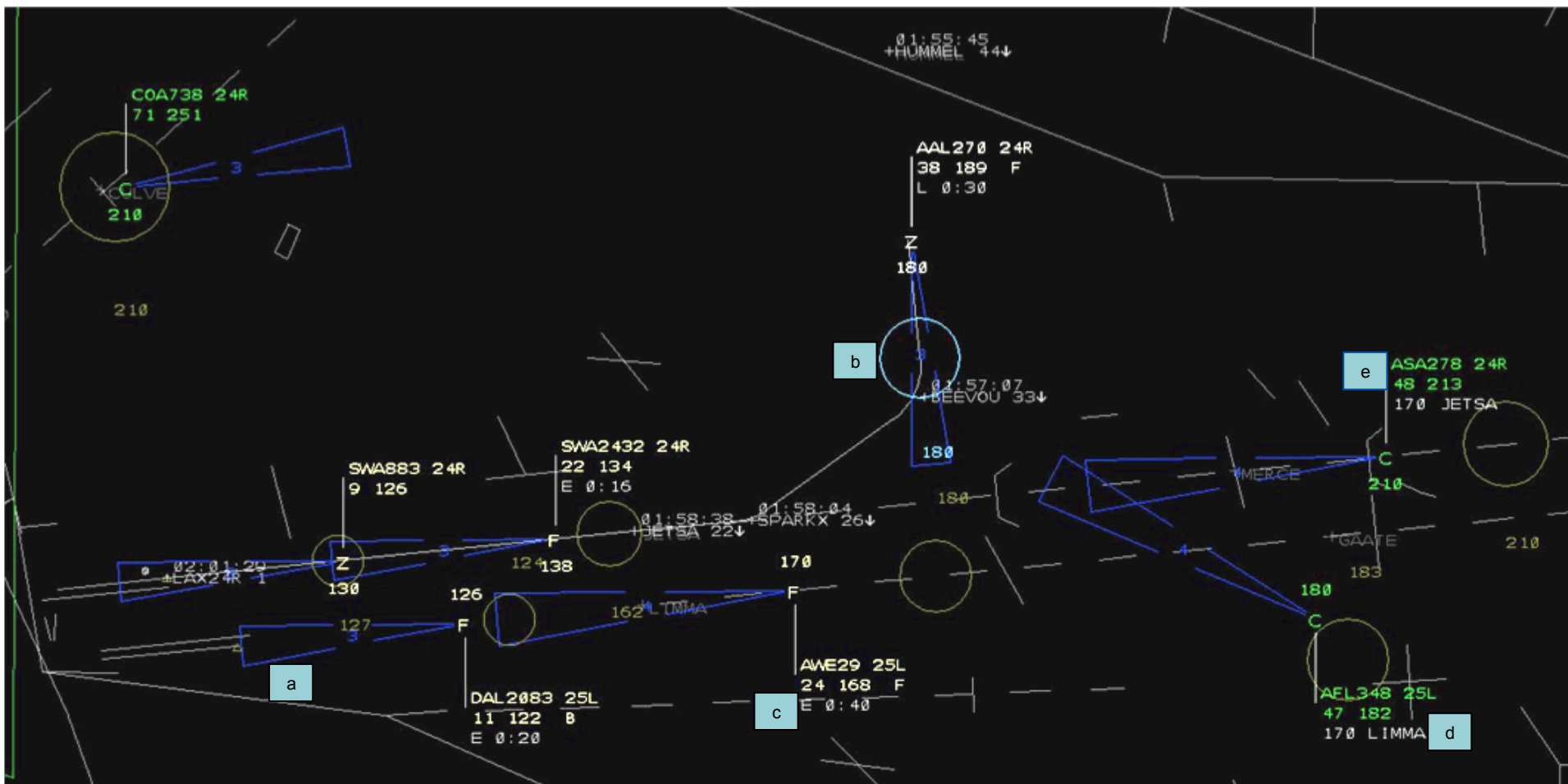


# ATC Lab Layout





# TSS Tools



- a. Spacing cones
- b. Slot marker
- c. Early/late indicator
- d. Fix
- e. Aircraft



# TSS Tools: Timeline

Timelines provide a graphical depiction of the relationship between the estimated time of arrival (ETA) and the scheduled time of arrival (STA)

ETA (green)

Weight Class

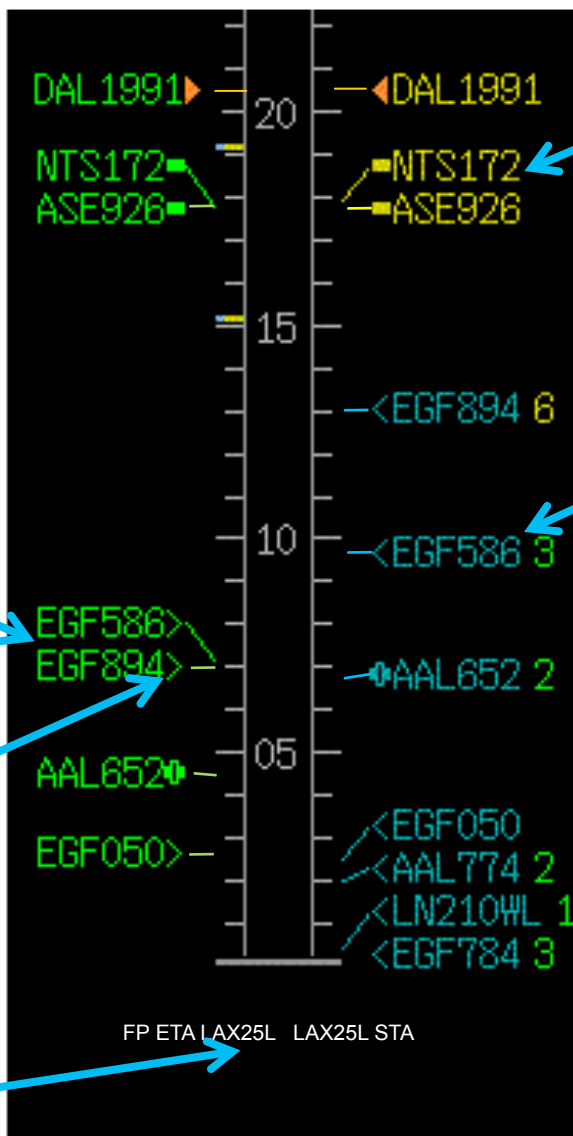
Runway

STA (yellow)

Frozen STA (blue)

4 Weight Classes

- Small
- Large
- B757
- Heavy





## TSS Tools: Early/Late (E/L) Indicators

- Enable users to quickly assess the schedule-conformance information for an aircraft if a single speed advisory cannot be calculated to resolve schedule conformance with a single speed with a 10 kt discrimination
- E/L indicators represent the difference between the ETA and STA to the next merge point or runway threshold

E/L indicators are displayed in the third line of the flight data block (FDB) if the difference is greater to or equal to 5 seconds

E=Early  
L=Late



Differences < 2 mins are displayed as 1:59...  
Differences > 2 mins are displayed in whole minutes

Sequence Number

Sequence Number:  
The number the aircraft is in sequence to the runway



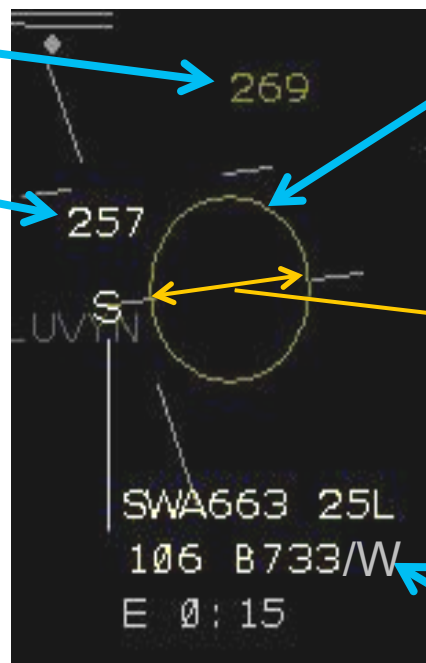
## TSS Tools: Slot Marker

- Circles on the display indicate where an aircraft should be at a given time if it were to:
  - Fly the RNAV/RNP route through the forecast wind field
  - Meet all published speed and altitude restrictions and
  - Arrive on time at its STA to the merge point or runway
- The slot speed or current indicated airspeed (IAS) of the slot marker is displayed next to the slot marker the current aircraft IAS is displayed next to the sector symbol

Slot speed

Aircraft speed

Dwelling on a FDB or a callsign on the timeline will highlight the corresponding aircraft's slot marker



O=Slot marker

Slot markers represent 15 seconds of flying time in diameter and decreases as the charted speed decreases

RNP/AR Capable = /W  
Will be displayed to the right of the aircraft type

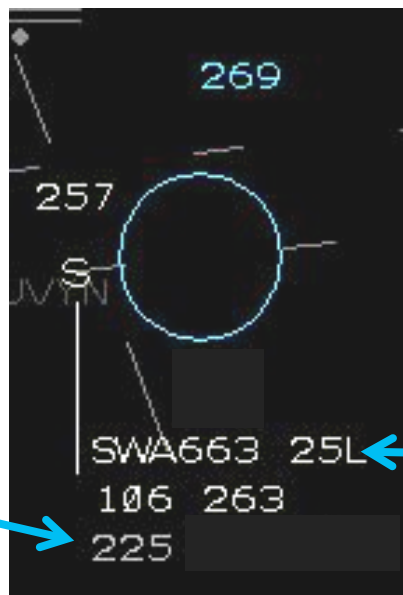


## TSS Tools: Speed Advisories

- Displayed when an aircraft's ETA exceeds 5 seconds from the STA and only if the predicted speed will correct the difference, otherwise the E/L indicator is displayed
- Flying the advised speed until rejoining the arrival procedure's nominal speed profile is predicted to place the aircraft back on schedule by the fix
- ***Speed advisories are suggested airspeeds and should only be used as a guide when assigning speeds***

The speed advisory is located in the third line of the FDB

Speed advisory



Runway assignment





## Roles and Responsibilities of Participants

# ZLA Center

- Clear aircraft for OPD and expected runway (*descend-via VISTA8 arrival expect runway 25L*)
  - RIIVR8 and SEVUE8 will need MERC7 or GATE7 transition depending upon runway
- Absorb delay to meet scheduled meter fix times

## TRACON Feeder

- Use the slot marker as a spatial target to adjust an aircraft to meet its STA
- Merge aircraft using TSS tools to issue speeds if appropriate
- Use speed advisories only as a guide when assigning speeds to meet the aircraft STA
- Ensure appropriate spacing to final controller
- System does account for compression effects but controller is still responsible for maintaining separation

# TRACON Final

- Clear aircraft for RNAV or RNP approach
- Merge aircraft using scheduling information
- Use TSS tools to issue speeds if appropriate
- Use normal approach procedures
- Ensure proper spacing on final approach

## Flight Crews

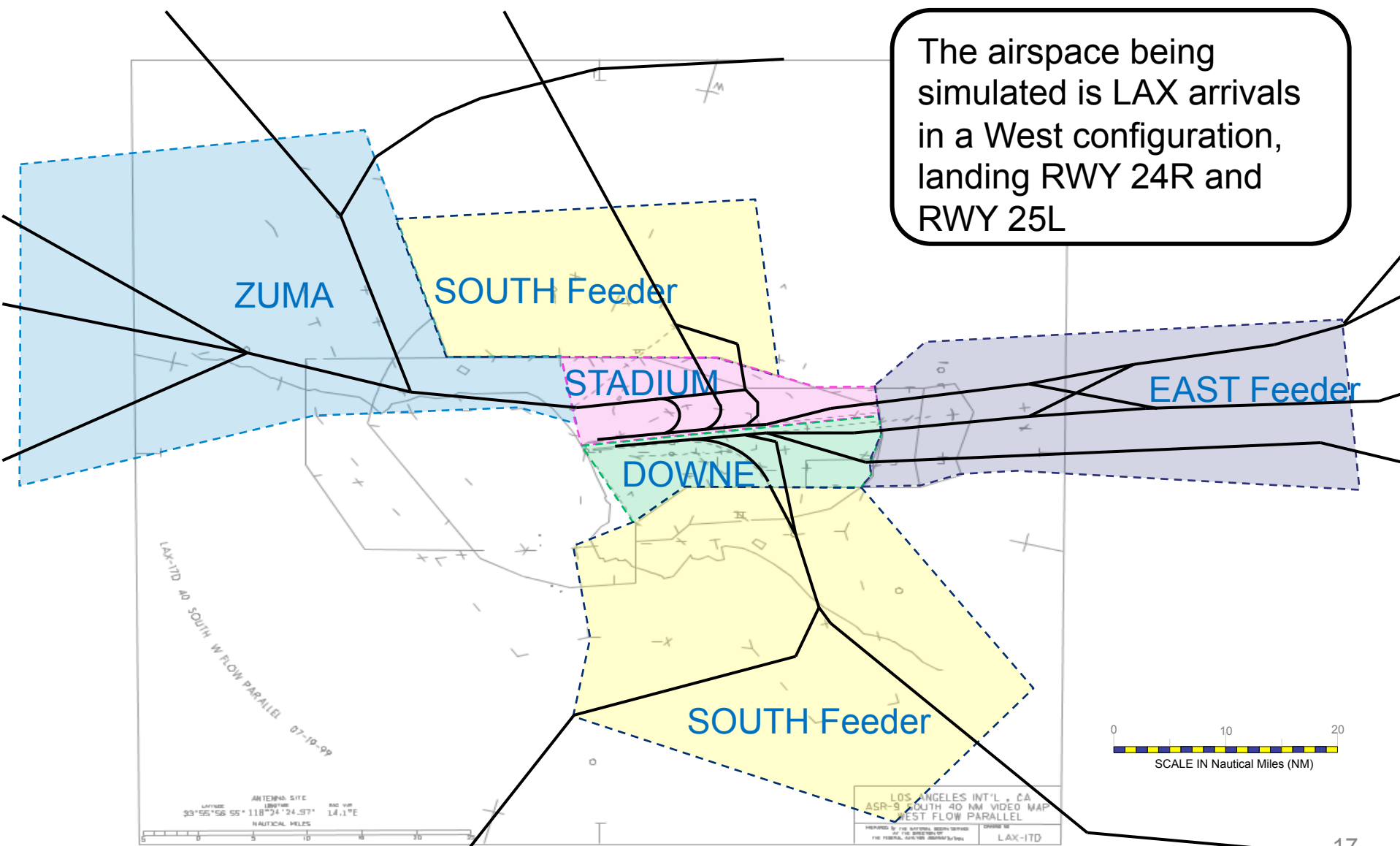
- Comply with controller instructions or advise if unable







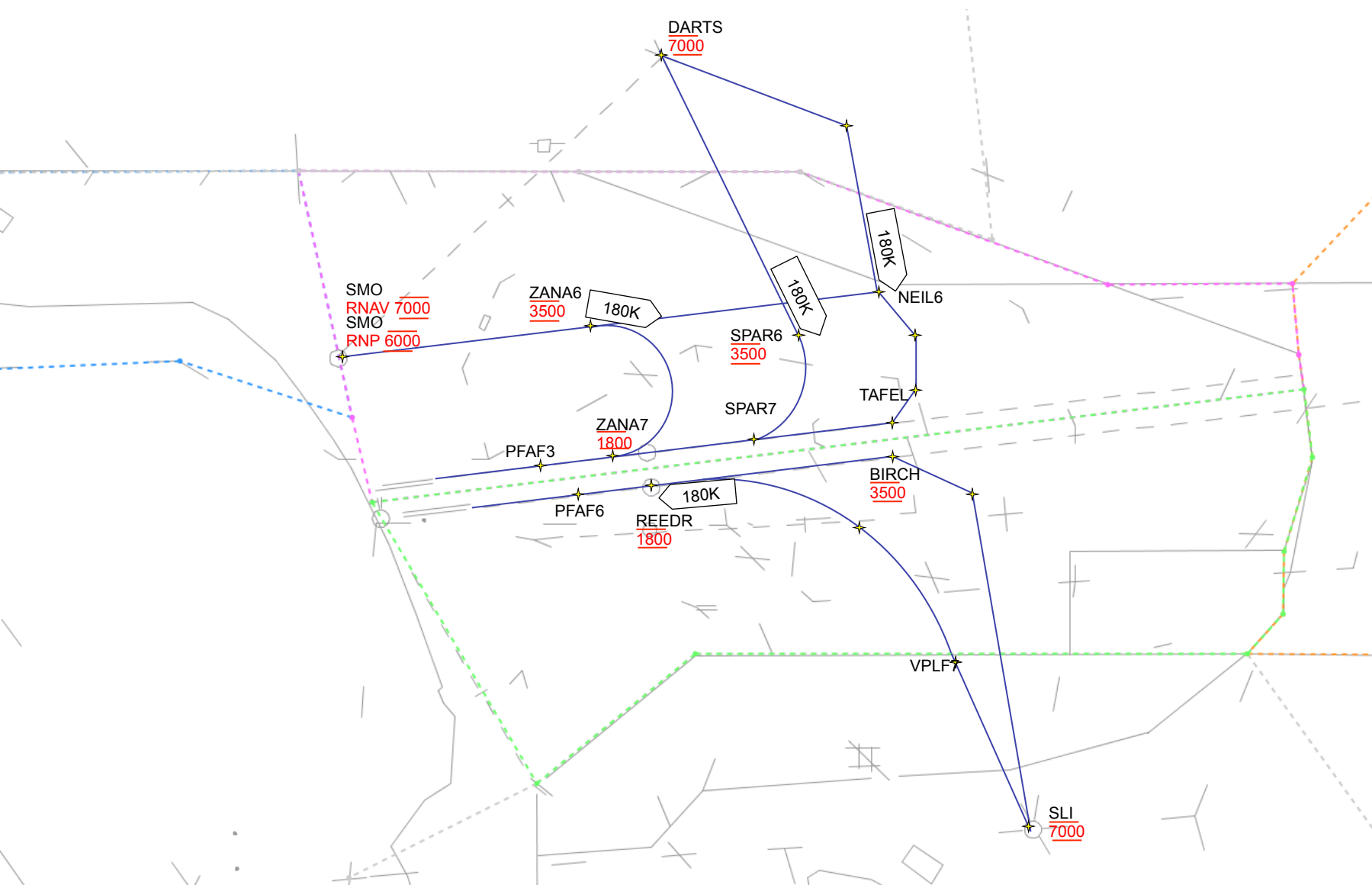
# LAX Airspace







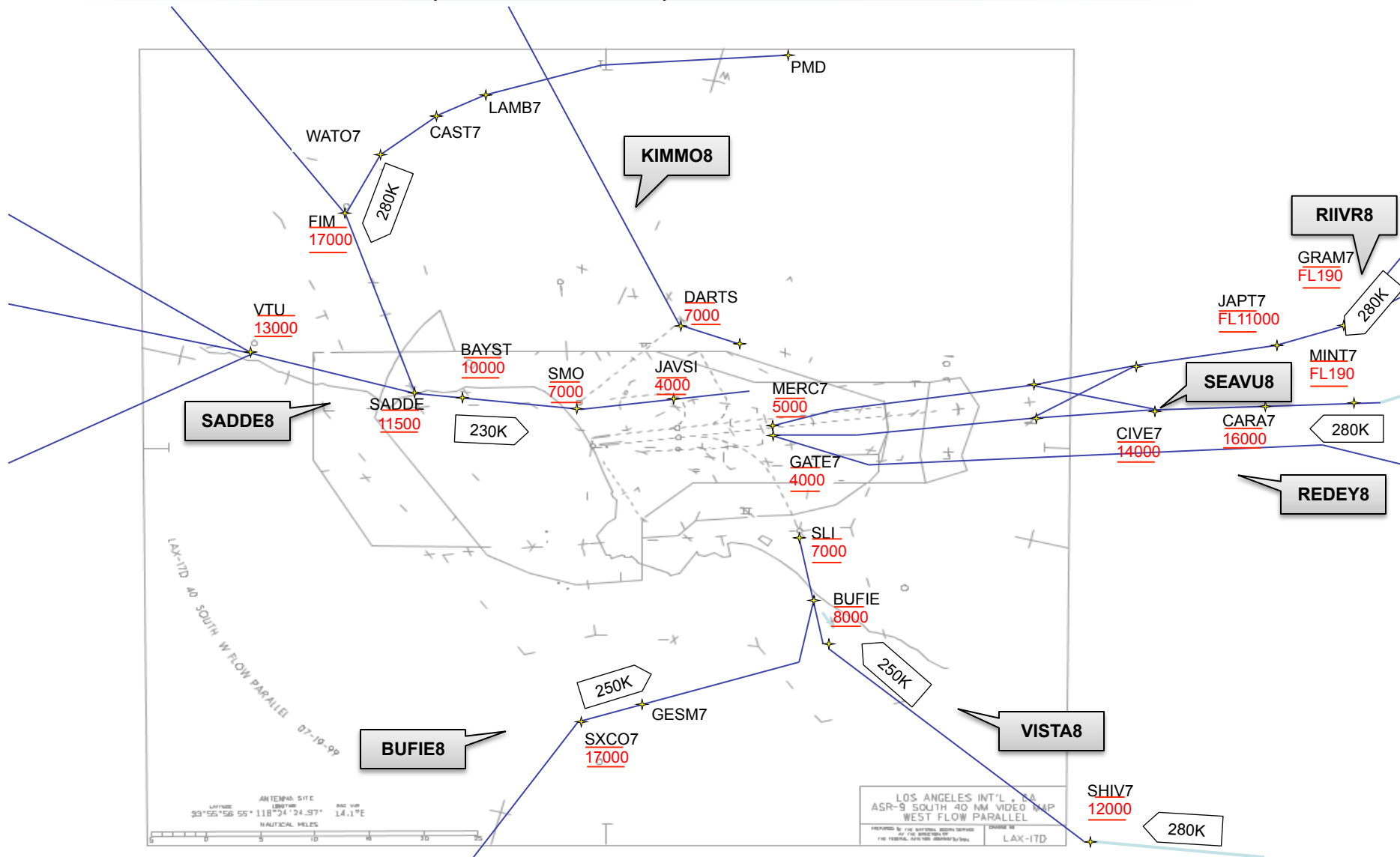
# LAX RNAV and RNP Arrivals







# LAX RNAV/OPD (Descend-via) Arrivals

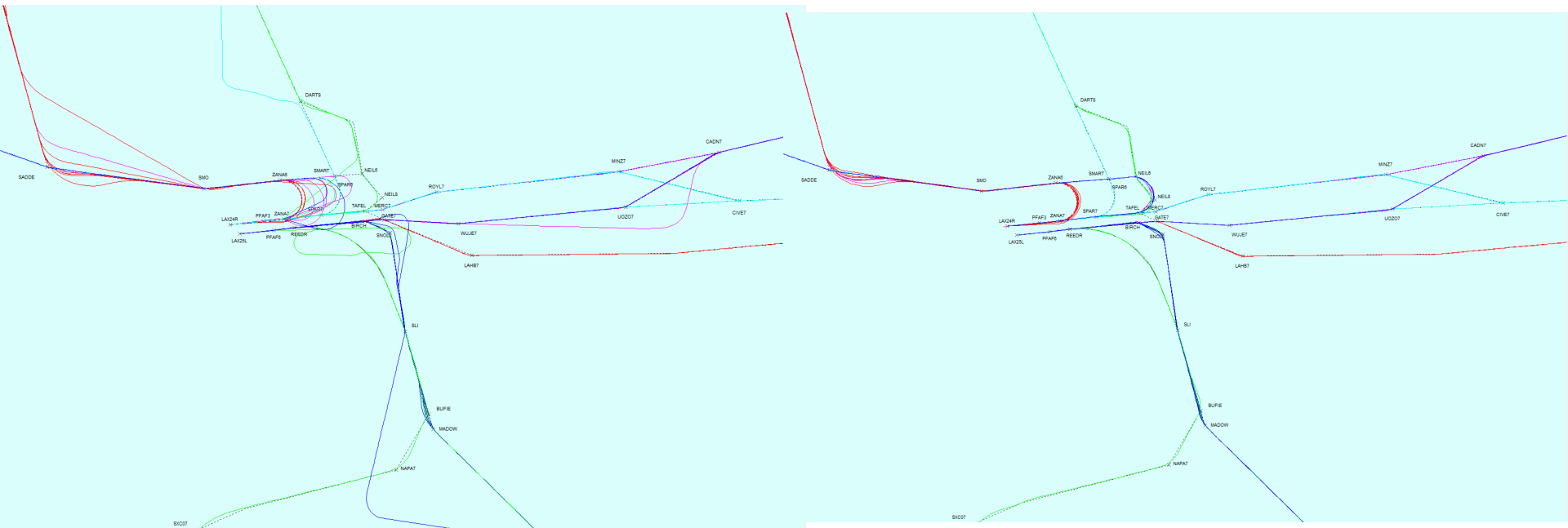




# Current Procedures vs Automation Assisted



## Simulation Radar Tracks for SoCal Operations with draft OAPM



Current Procedures

Automation Assisted



# TSS 1 simulations Study Summary

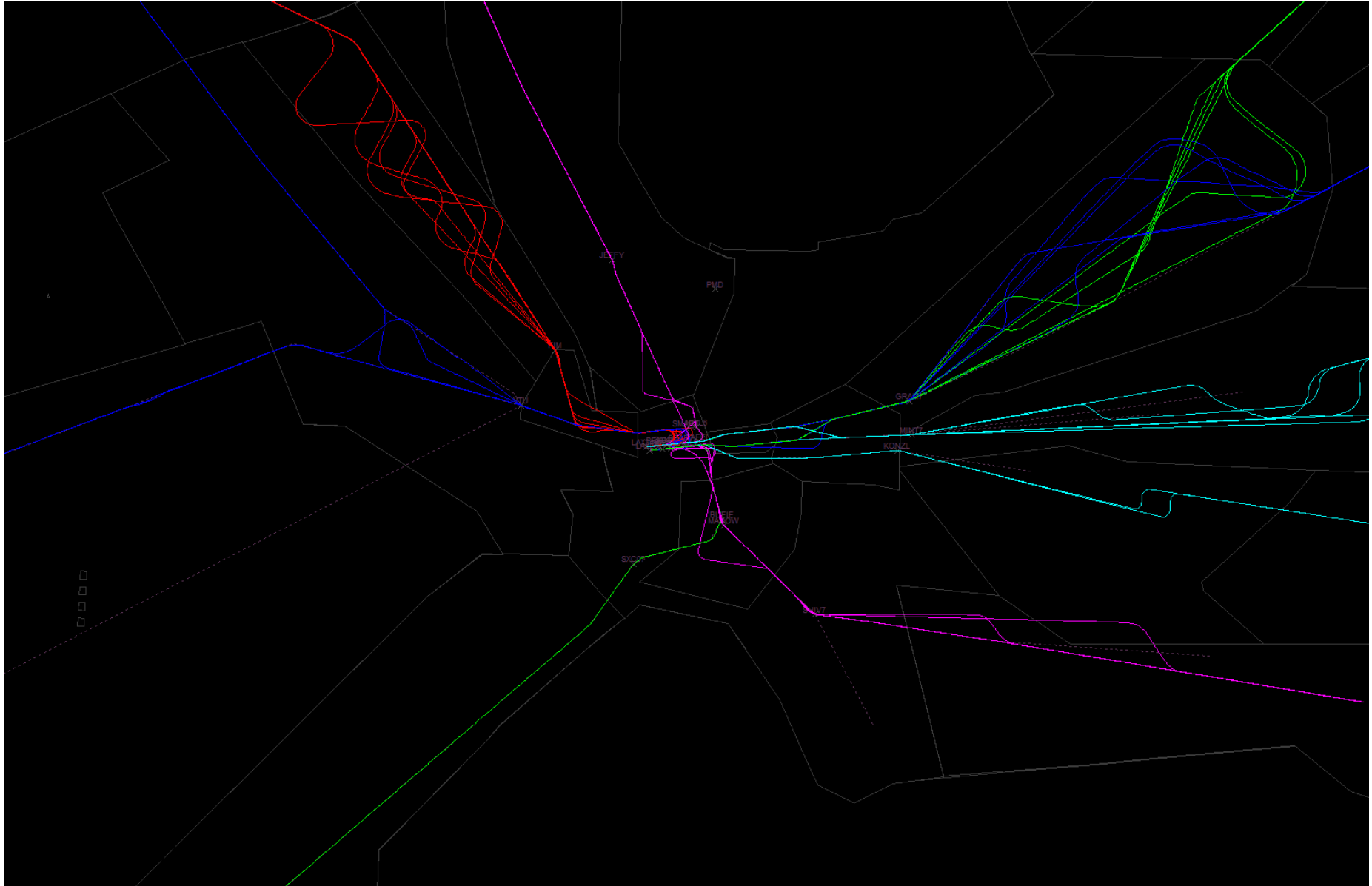
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- TSS (ATD-1 Ground tools) greatly assists in the ability to perform multiple RNP arrival procedures simultaneously with current procedures during heavily congested periods
- Controller preference and RNP compliance conformance highest with full ATD-1 controller advisories (Slot Markers, Timelines and Speed Advisories/E-L)
- Merging arrival routing procedures a significant factor in an efficient operations
- Results from this simulation are considered anecdotal and only provide insight for future work

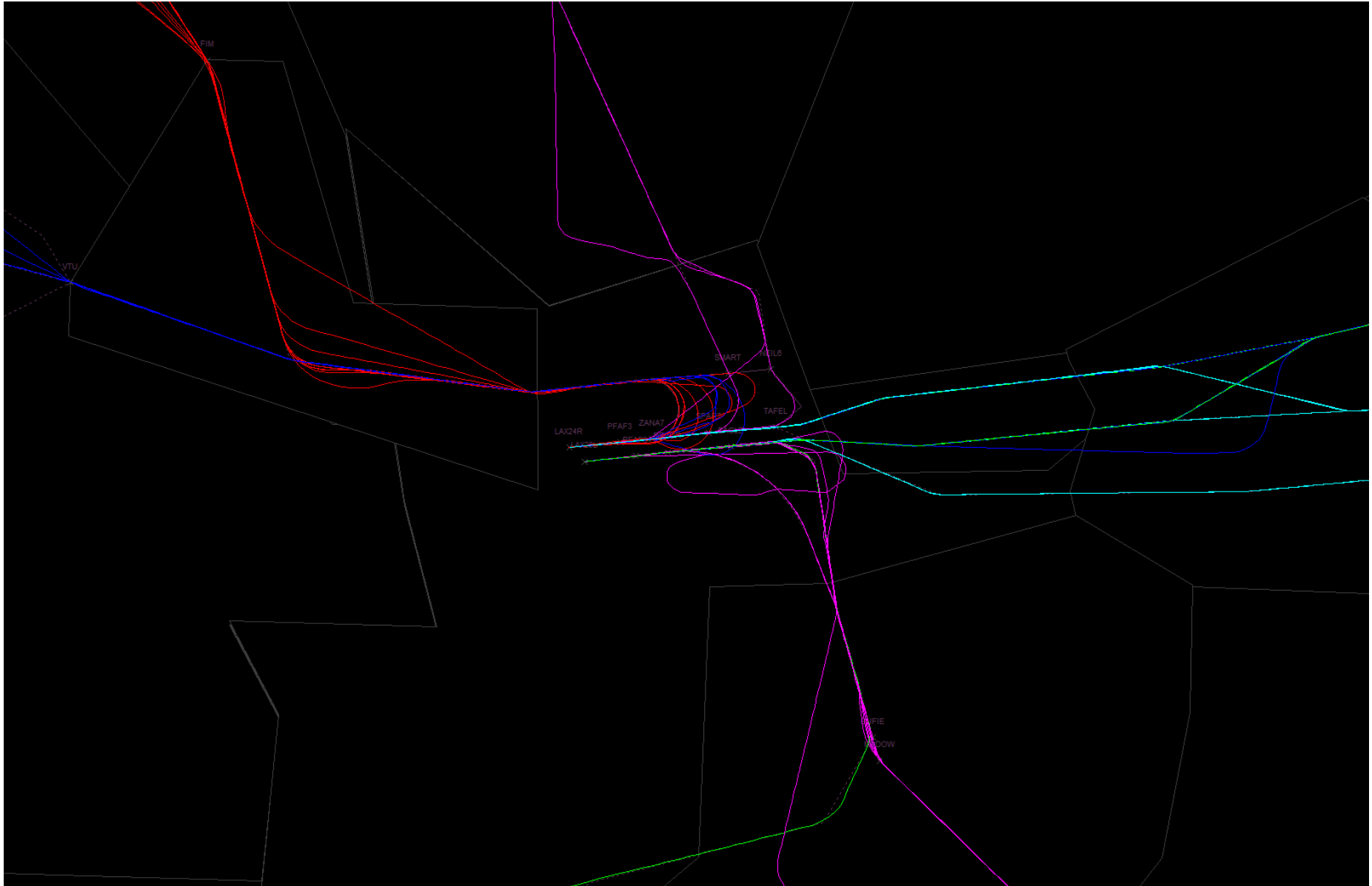


# TSS-1 Today's Tools/Same Winds



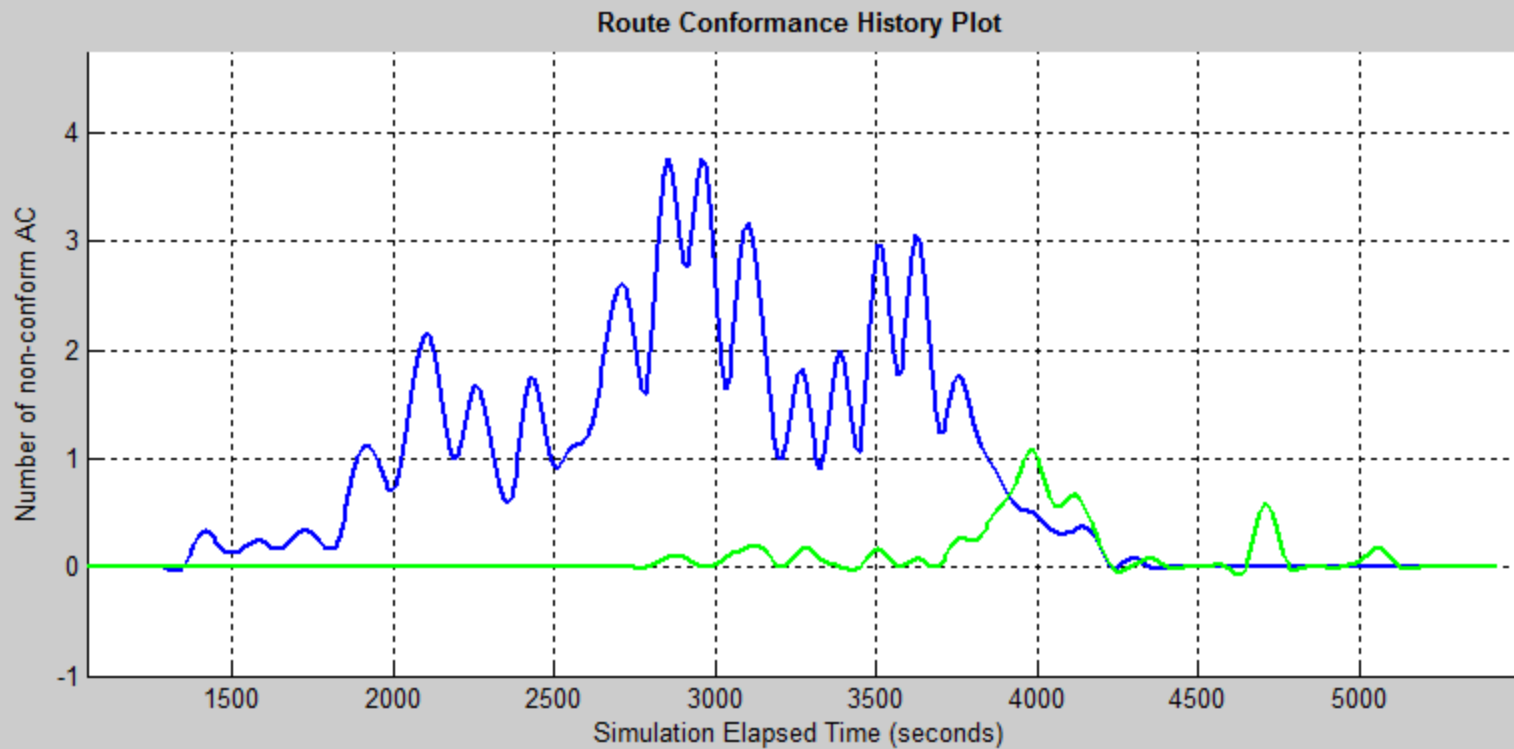


# TSS-1 Today's Tools/Same Winds





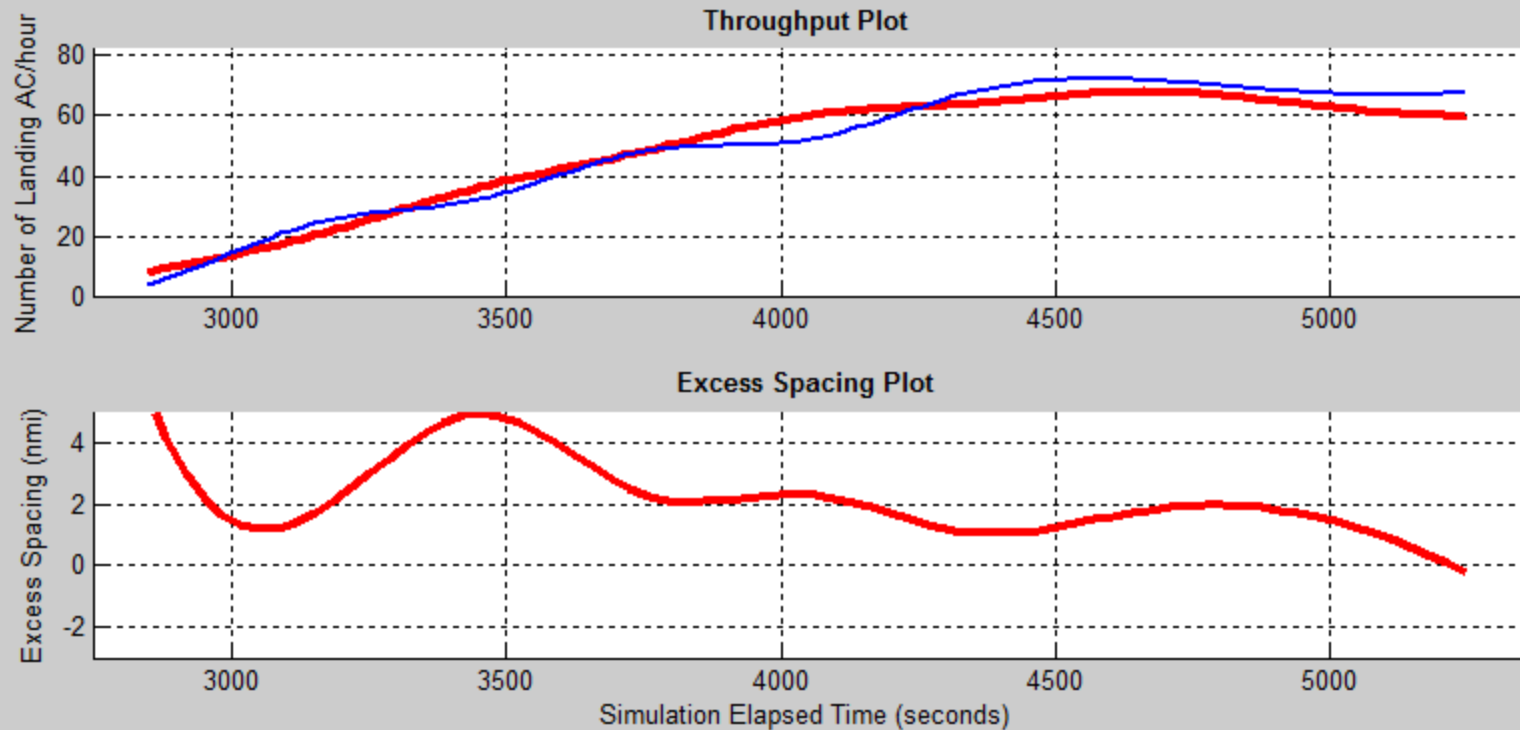
# TSS-1 Route Conformance Today's Tools/Same Winds



— TRACO N — Center

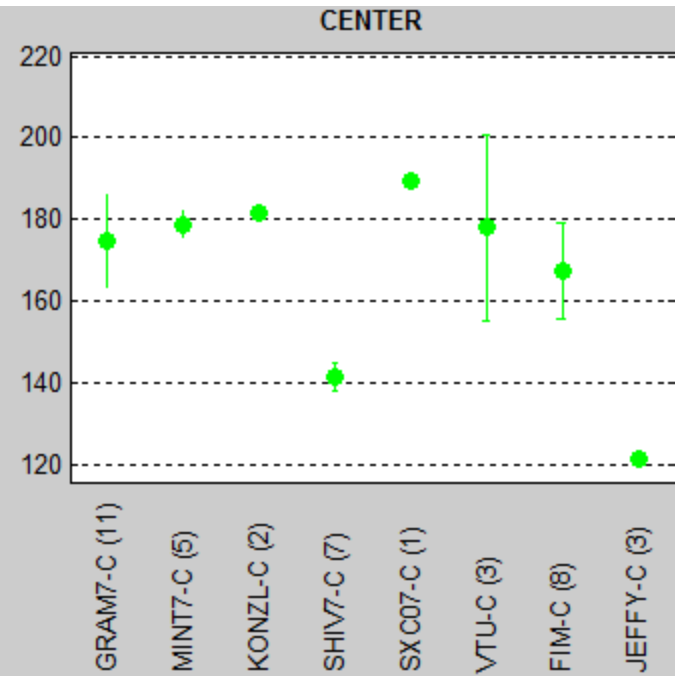
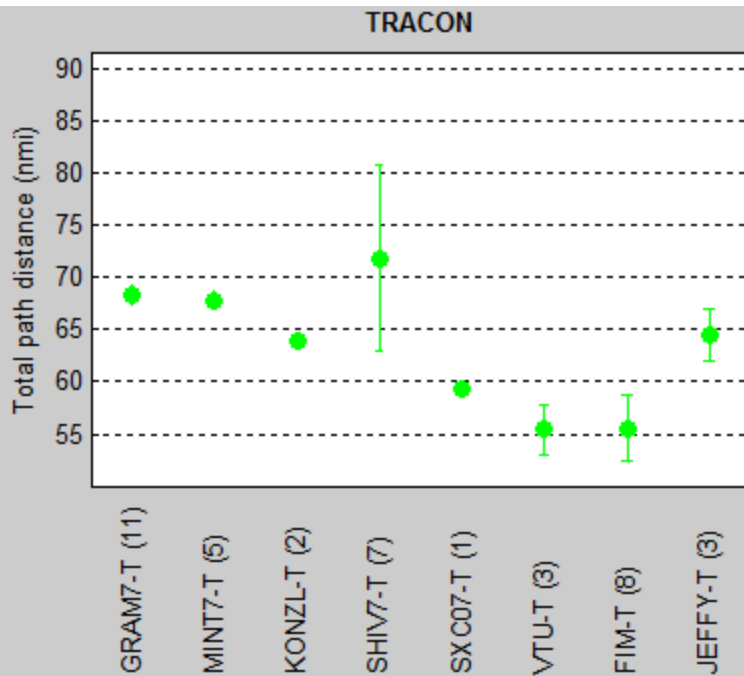


# TSS-1 Throughput Today's Tools/Same Winds



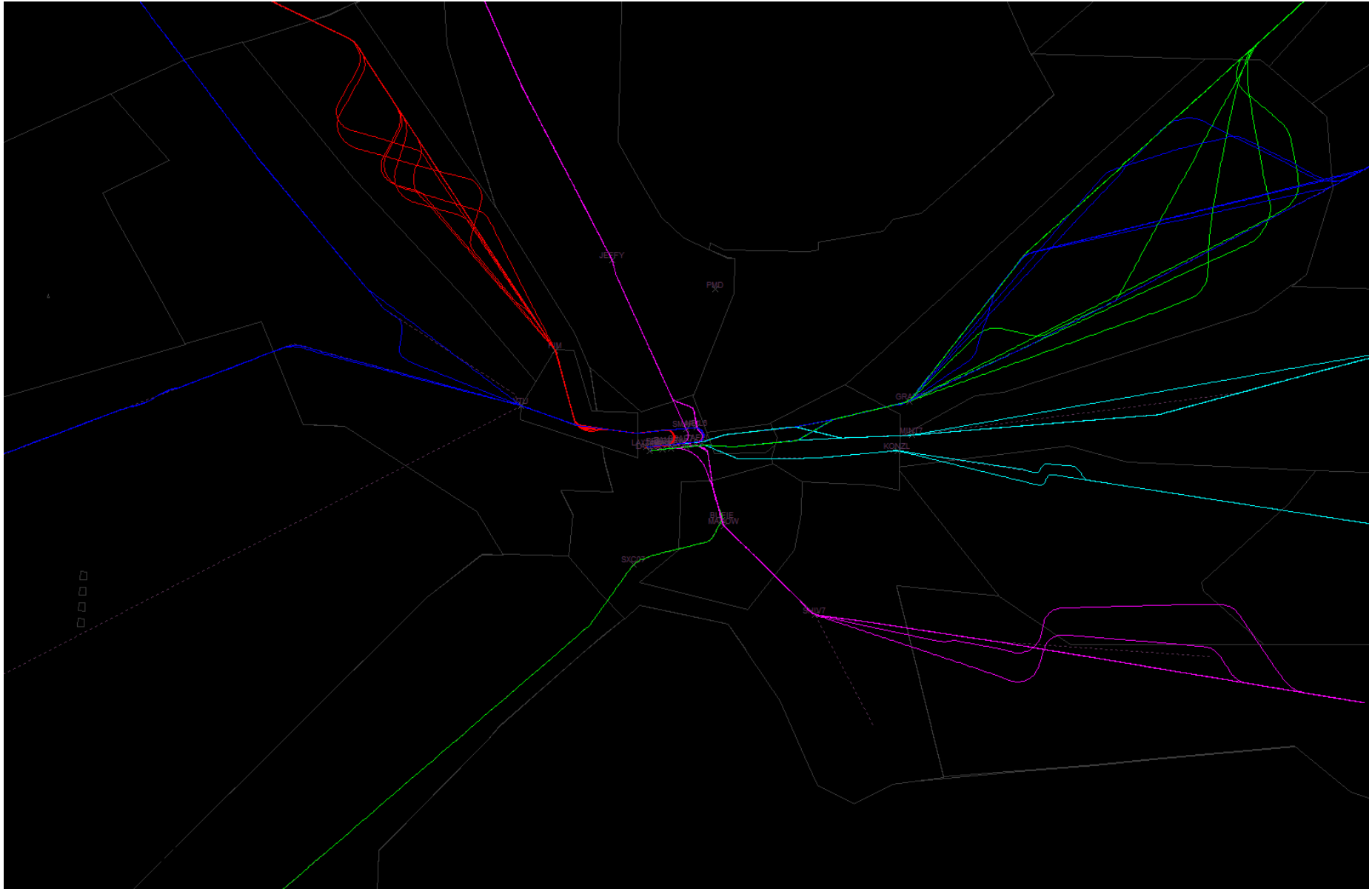


# TSS-1 Path Distance Today's Tools/Same Winds



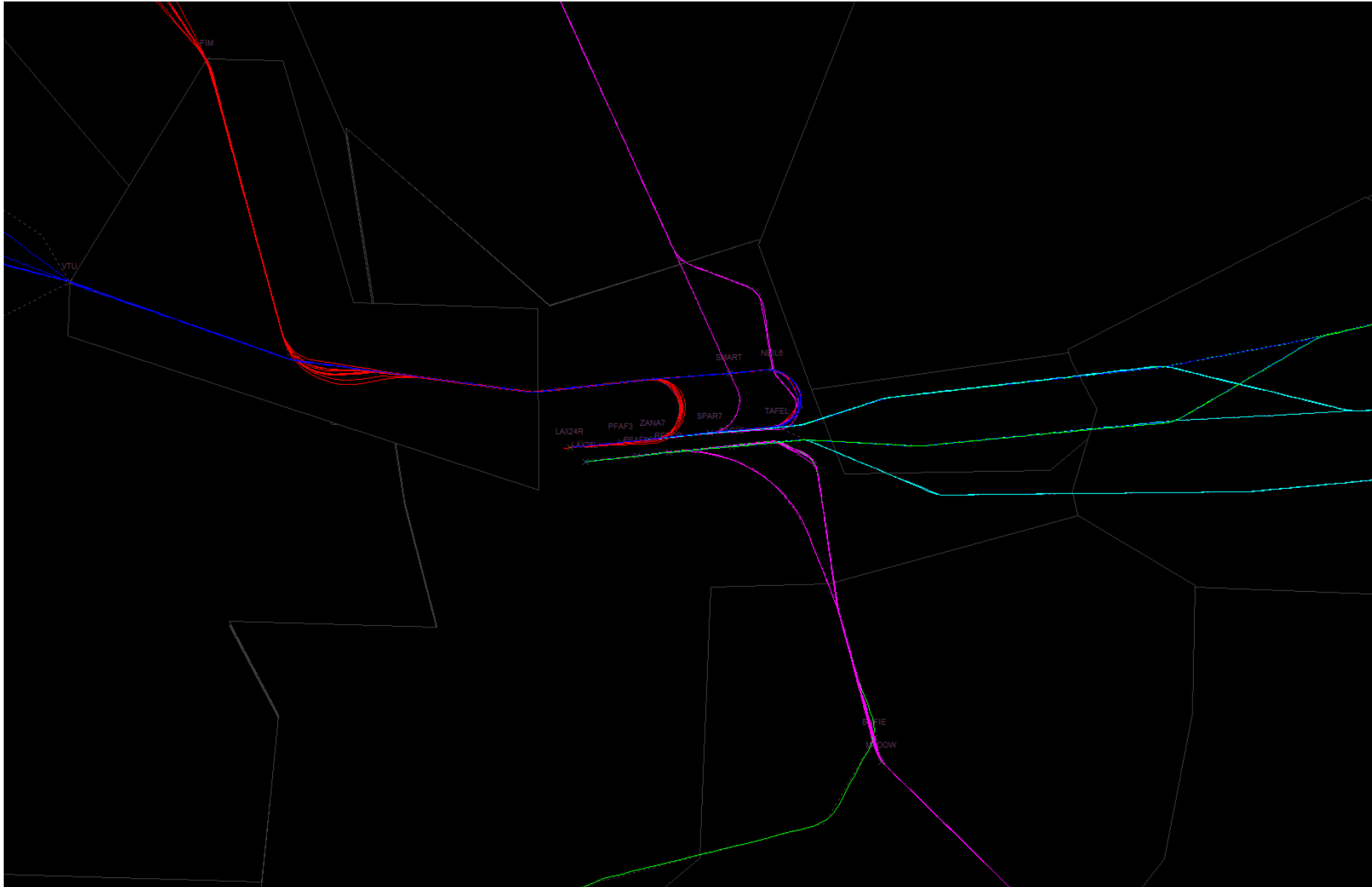


# TSS-1 Run 10 (TSS Tools/Same Winds)



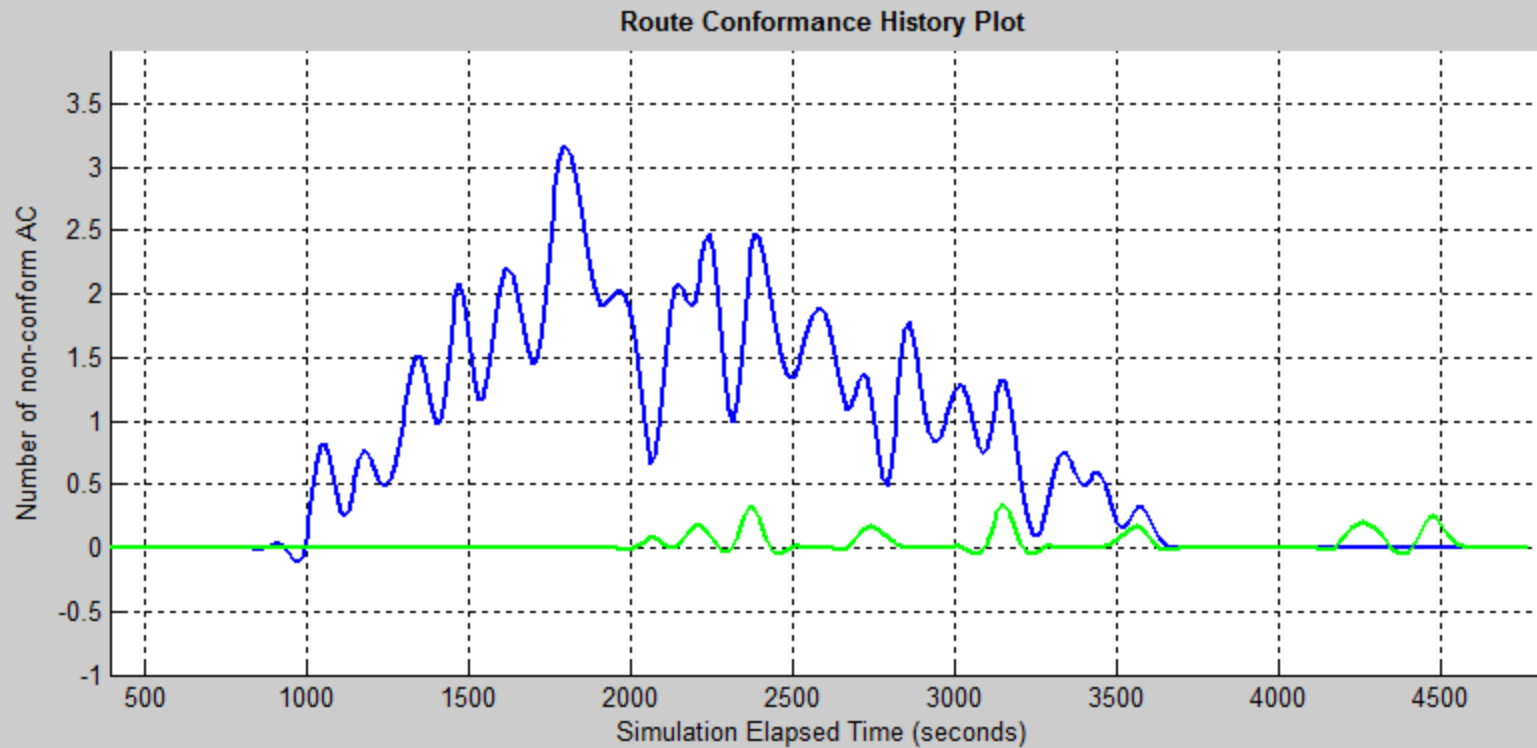


# TSS-1 Run 10 (TSS Tools/Same Winds)





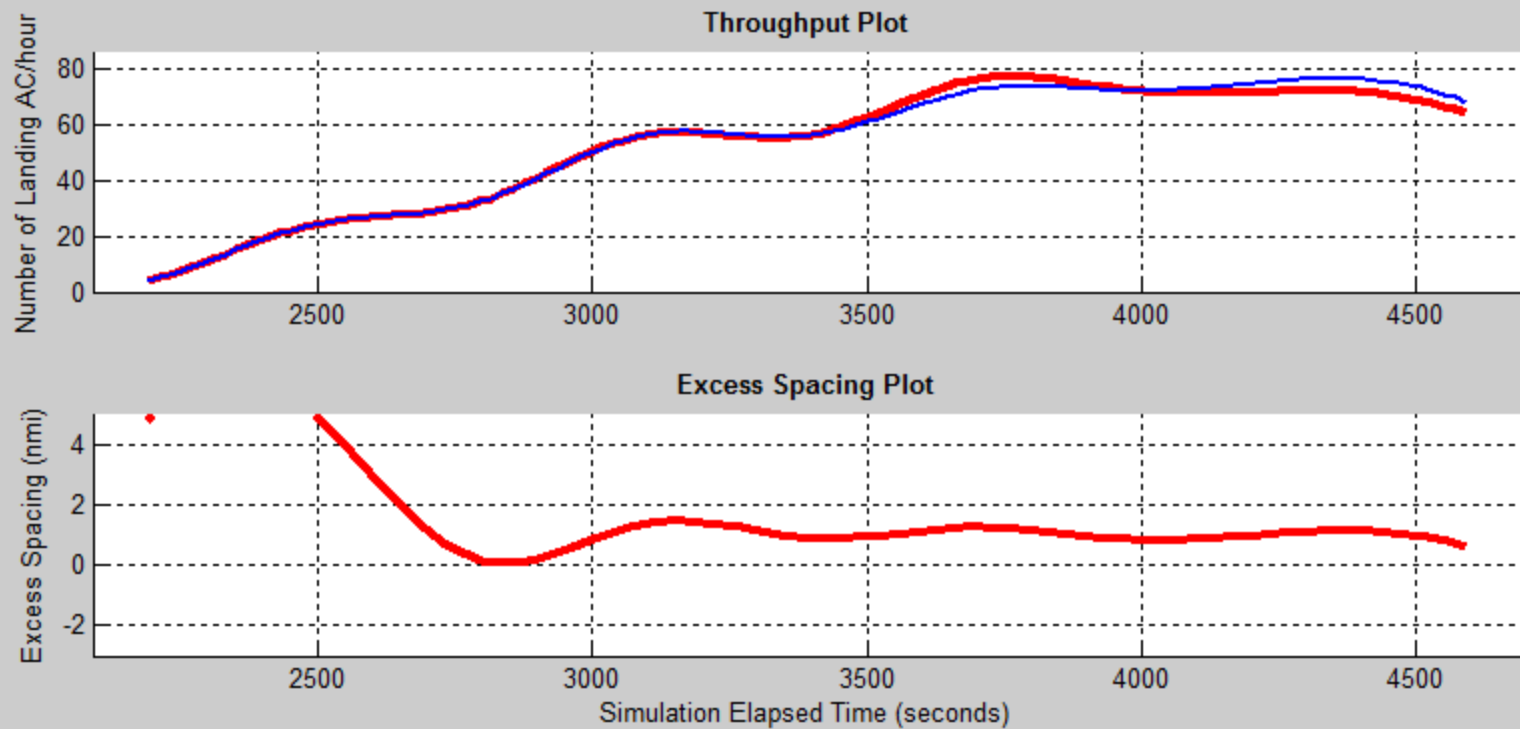
# TSS-1 Run-10 – Route Conformance (T/W)



— TRACO — Center  
N

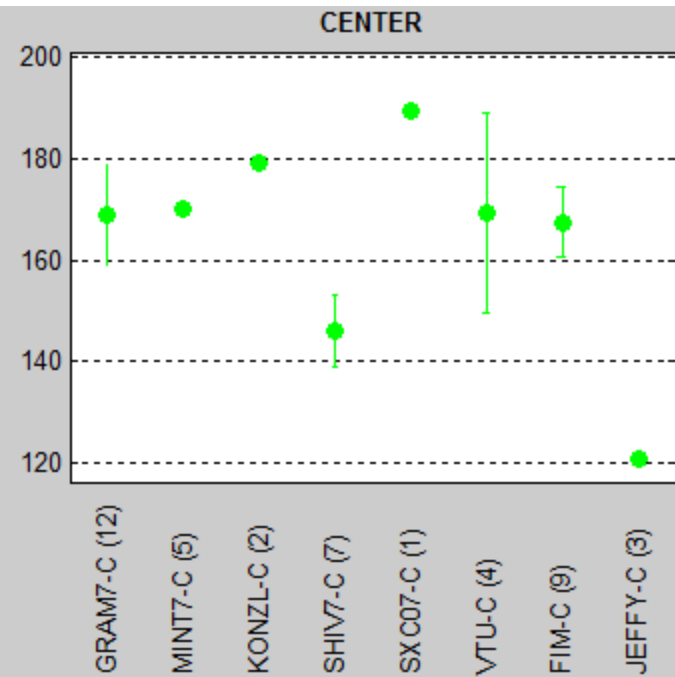
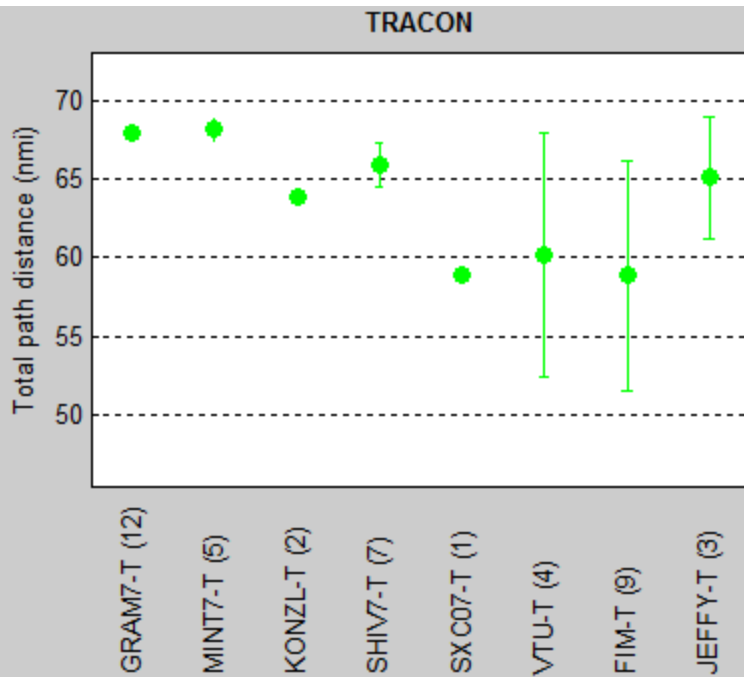


# TSS-1 Run-10 – Throughput (T/W)



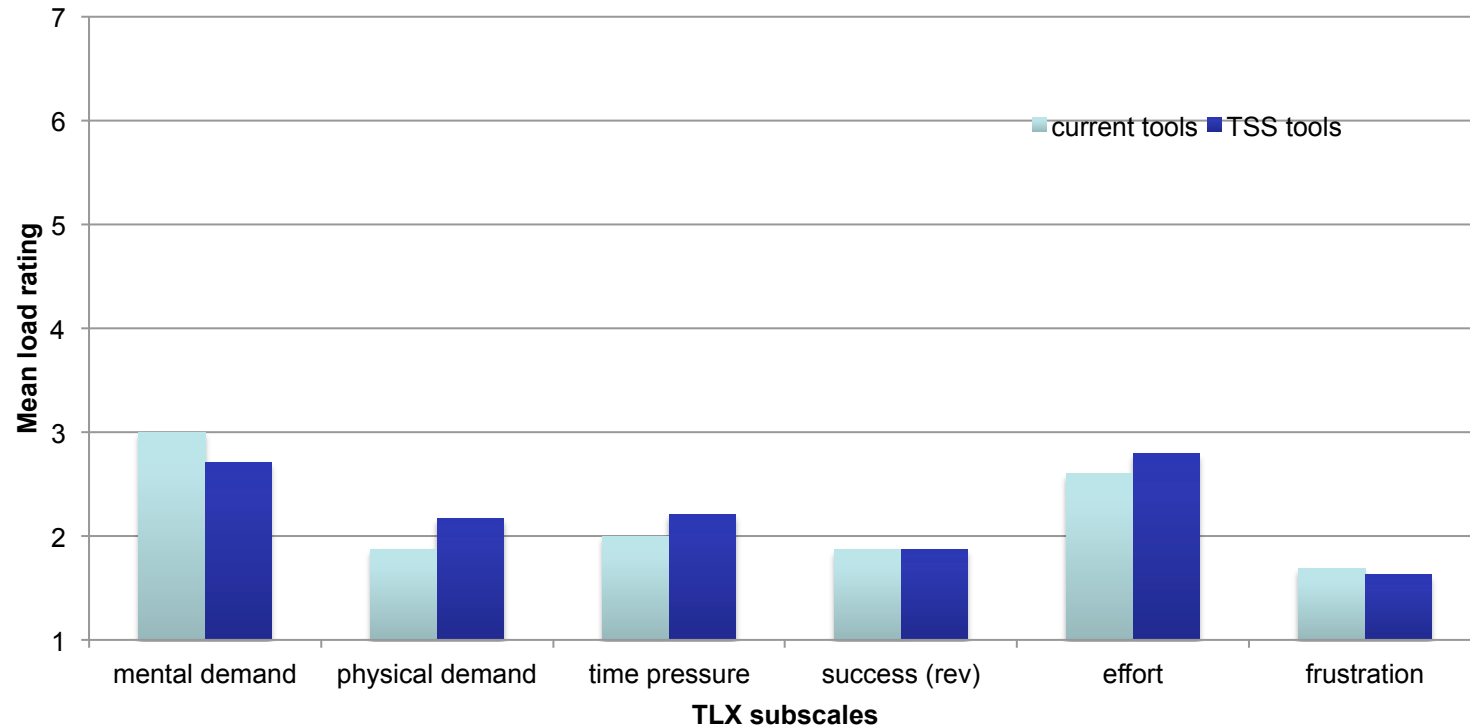


# TSS-1 Path Distance (T/W)



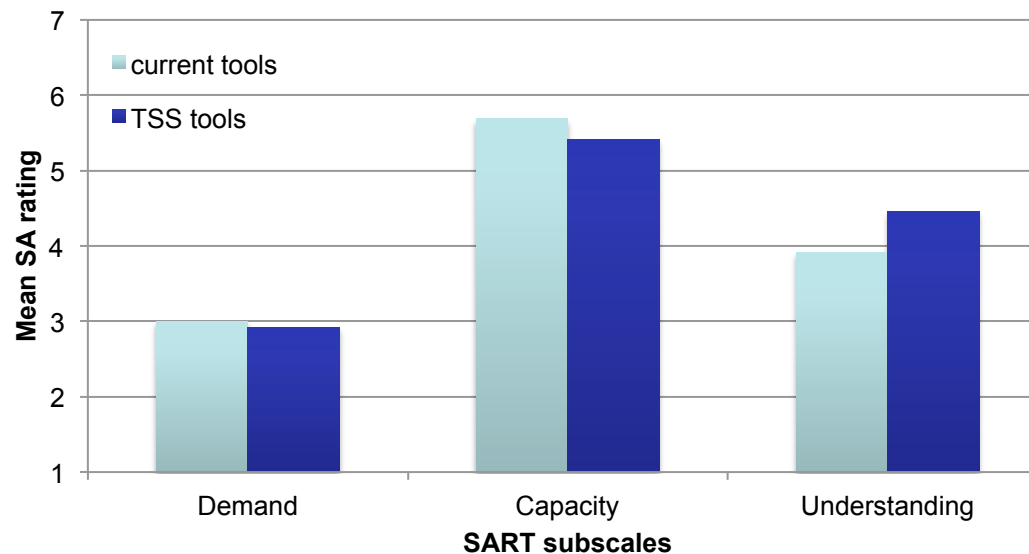


# Human Factors Workload Results (TLX)





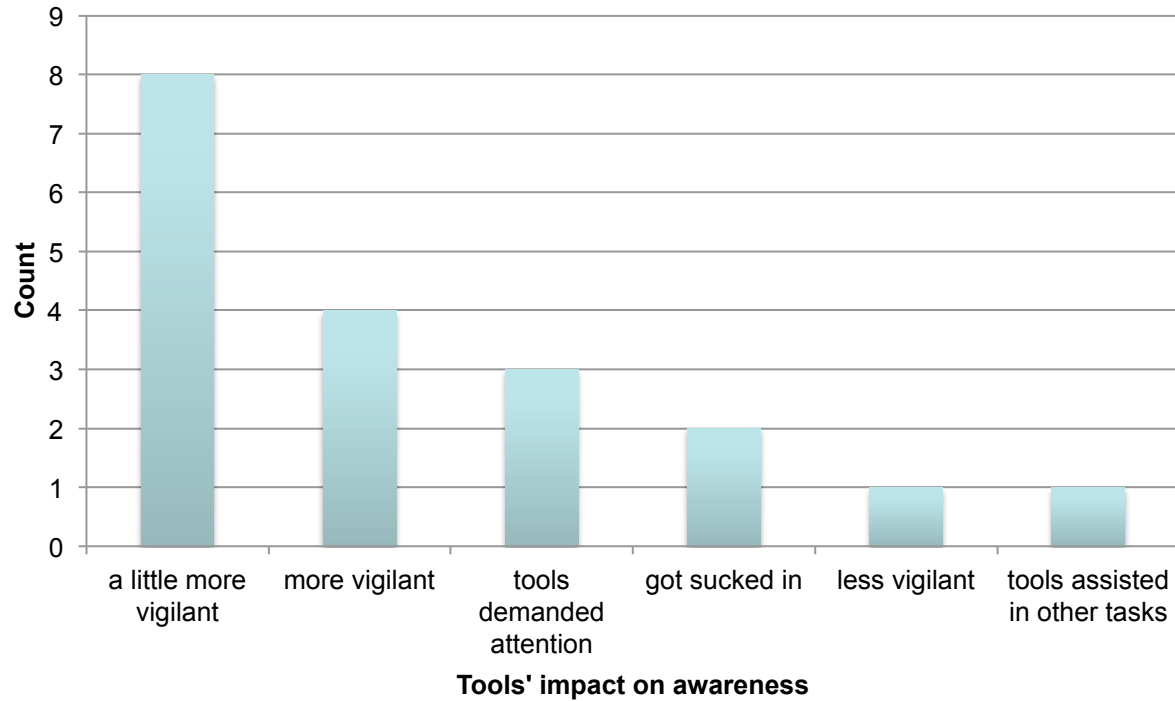
# Human Factors Situation Awareness Results (SART Combined)







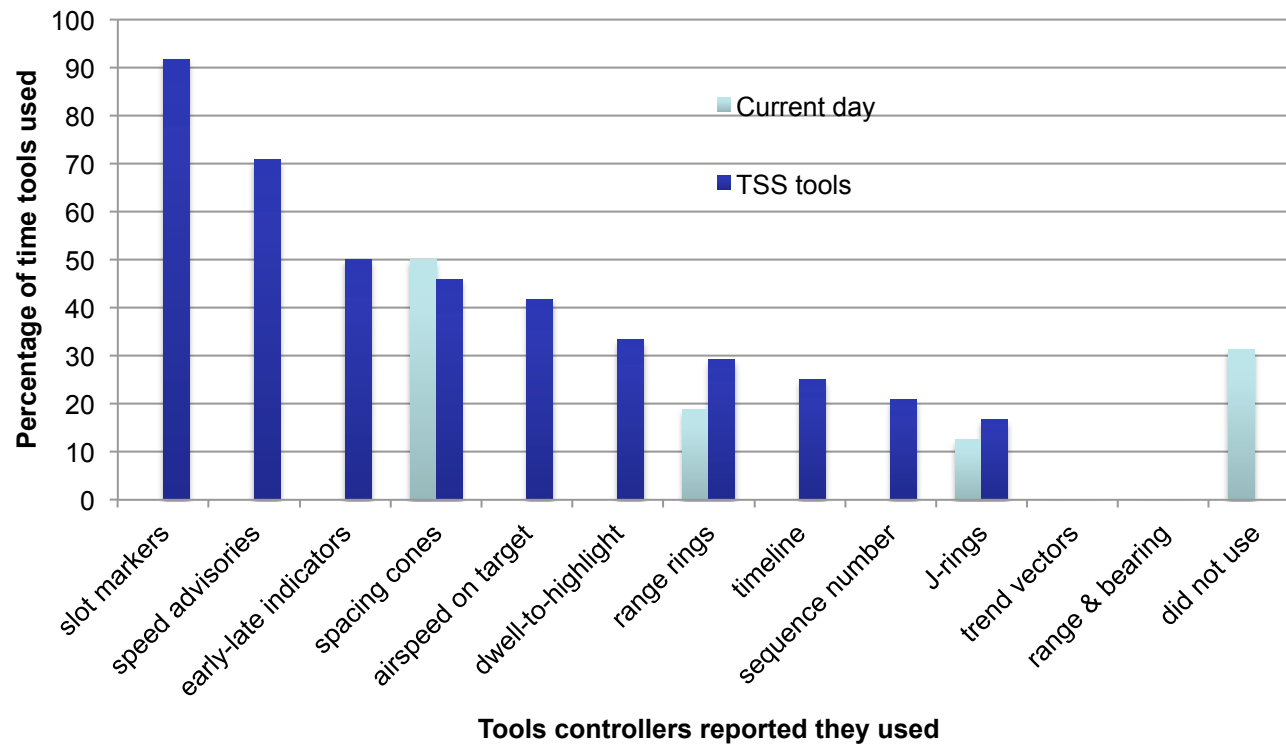
# General Situation Awareness Results







# Tool Use Results





# Summary and Lessons Learned

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- rTMA-TM, CMS(MACS) and MACS can be quickly adapted to a complex “notional” advance airspace (RNAV and RNP for LAX)
- NATCA controller team indicated that these automation technologies had a great potential to aid them in conducting mixed RNAV and RNP procedures
- FAA has proceeded with the acceleration of the TSS functionality to support PBN operations within TBFM and STARS
- Requirement to understand the airspace design implications on the the automation adaptation, ie a bad airspace topology will led to capacity reductions
- At least several days of both airspace and tool training is necessary for results that have any significance beyond anecdotal ( controllers were modifying both use techniques and perceptions until the last runs)